



US009435347B2

(12) **United States Patent**
Danguy et al.

(10) **Patent No.:** **US 9,435,347 B2**
(45) **Date of Patent:** **Sep. 6, 2016**

(54) **TURBOPUMP, IN PARTICULAR FOR FEEDING ROCKET ENGINES**

(75) Inventors: **Francois Danguy**, Tourny (FR);
Laurent Fabbri, Gasny (FR);
Sebastien Guingo, Pacy sur Eure (FR)

(73) Assignee: **SNECMA**, Paris (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 803 days.

(21) Appl. No.: **13/820,308**

(22) PCT Filed: **Aug. 31, 2011**

(86) PCT No.: **PCT/FR2011/052001**

§ 371 (c)(1),
(2), (4) Date: **May 8, 2013**

(87) PCT Pub. No.: **WO2012/089943**

PCT Pub. Date: **Jul. 5, 2012**

(65) **Prior Publication Data**

US 2013/0227931 A1 Sep. 5, 2013

(30) **Foreign Application Priority Data**

Sep. 3, 2010 (FR) 10 57013

(51) **Int. Cl.**

F04D 29/047 (2006.01)

F02K 9/46 (2006.01)

F04D 7/02 (2006.01)

F04D 13/04 (2006.01)

F04D 29/049 (2006.01)

(52) **U.S. Cl.**

CPC **F04D 29/047** (2013.01); **F02K 9/46** (2013.01); **F04D 7/02** (2013.01); **F04D 13/04** (2013.01); **F04D 29/049** (2013.01)

(58) **Field of Classification Search**

CPC F02K 9/46; F02K 9/48; F04D 29/042;
F04D 29/047; F04D 29/0473; F04D 29/049;
F04D 27/057; F04D 29/14; F04D 7/02;
F04D 13/04

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,756,323 A * 4/1930 Wilfley F04D 7/06
415/217.1

2,475,316 A 7/1949 Garraway

(Continued)

FOREIGN PATENT DOCUMENTS

DE EP 1477683 A2 * 11/2004 F04D 13/0613

GB 727 649 4/1955

JP H07-4381 1/1995

OTHER PUBLICATIONS

Space Shuttle Main Engine Orientation [1998], Boeing, BC98-04.*

(Continued)

Primary Examiner — Phutthiwat Wongwian

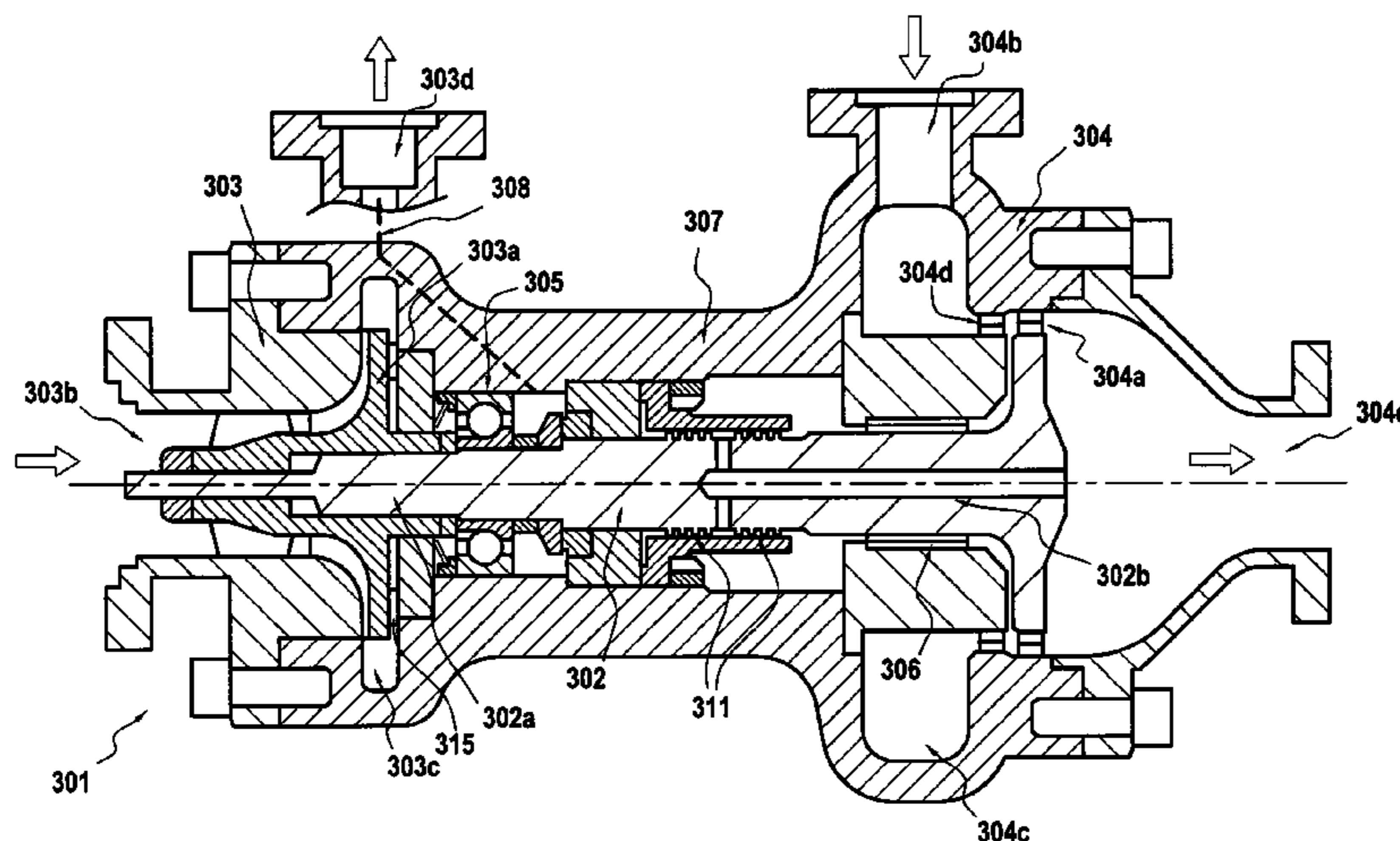
Assistant Examiner — Jason H Duger

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A turbopump for feeding a low-thrust rocket engine comprises a pump, a turbine, and a common rotary shaft connected to the pump and to the turbine. First and second bearings closer respectively to the pump and to the turbine serve to support the common shaft. The second bearing is a hydrodynamic bearing connected to a gas supply source, and the turbopump also includes at least one dynamic sealing gasket around the shaft and interposed between the first and second bearings.

15 Claims, 5 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2,750,892 A 6/1956 Johnson
2,839,005 A 6/1958 Means
3,581,504 A * 6/1971 Andrus F02K 9/48
415/111
4,242,039 A * 12/1980 Villard F04D 29/2266
415/112
4,255,095 A 3/1981 Goulvestre et al.
4,430,011 A 2/1984 Kun
5,209,652 A 5/1993 Fischer et al.
5,403,165 A * 4/1995 Lehe F01D 11/22
417/406
5,529,464 A 6/1996 Emerson et al.

6,058,715 A * 5/2000 Strang B64D 13/06
62/172
7,391,125 B2 * 6/2008 Ganev H02K 9/18
290/1 A
7,402,020 B2 * 7/2008 Beers F04D 25/04
415/1

OTHER PUBLICATIONS

International Search Report issued Nov. 4, 2011 in PCT/FR11/
052001 Filed Aug. 31, 2011.

Office Action issued Mar. 7, 2016 in Japanese Patent Application
No. 2013-526537 (in English language).

* cited by examiner

FIG. 1

Background Art

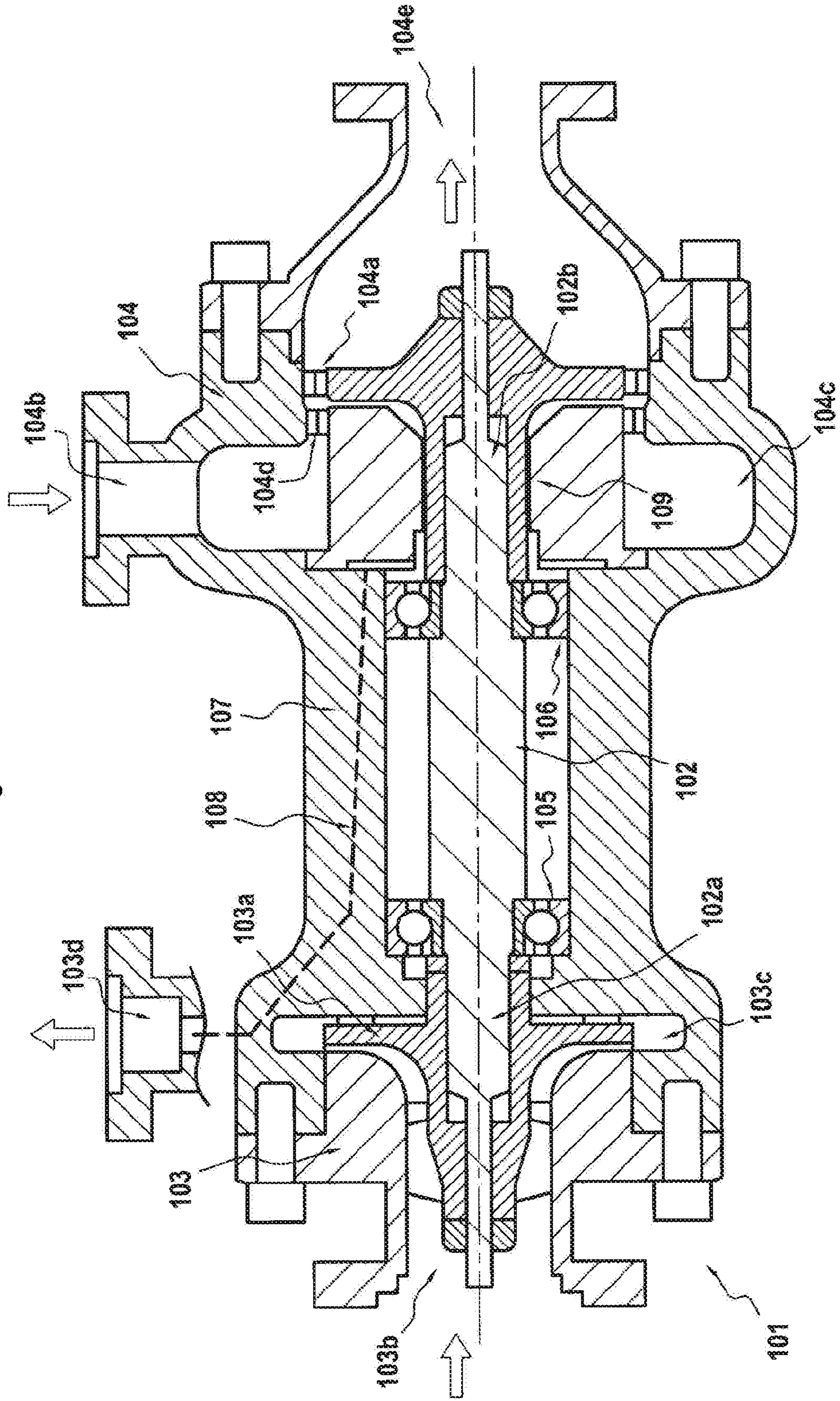
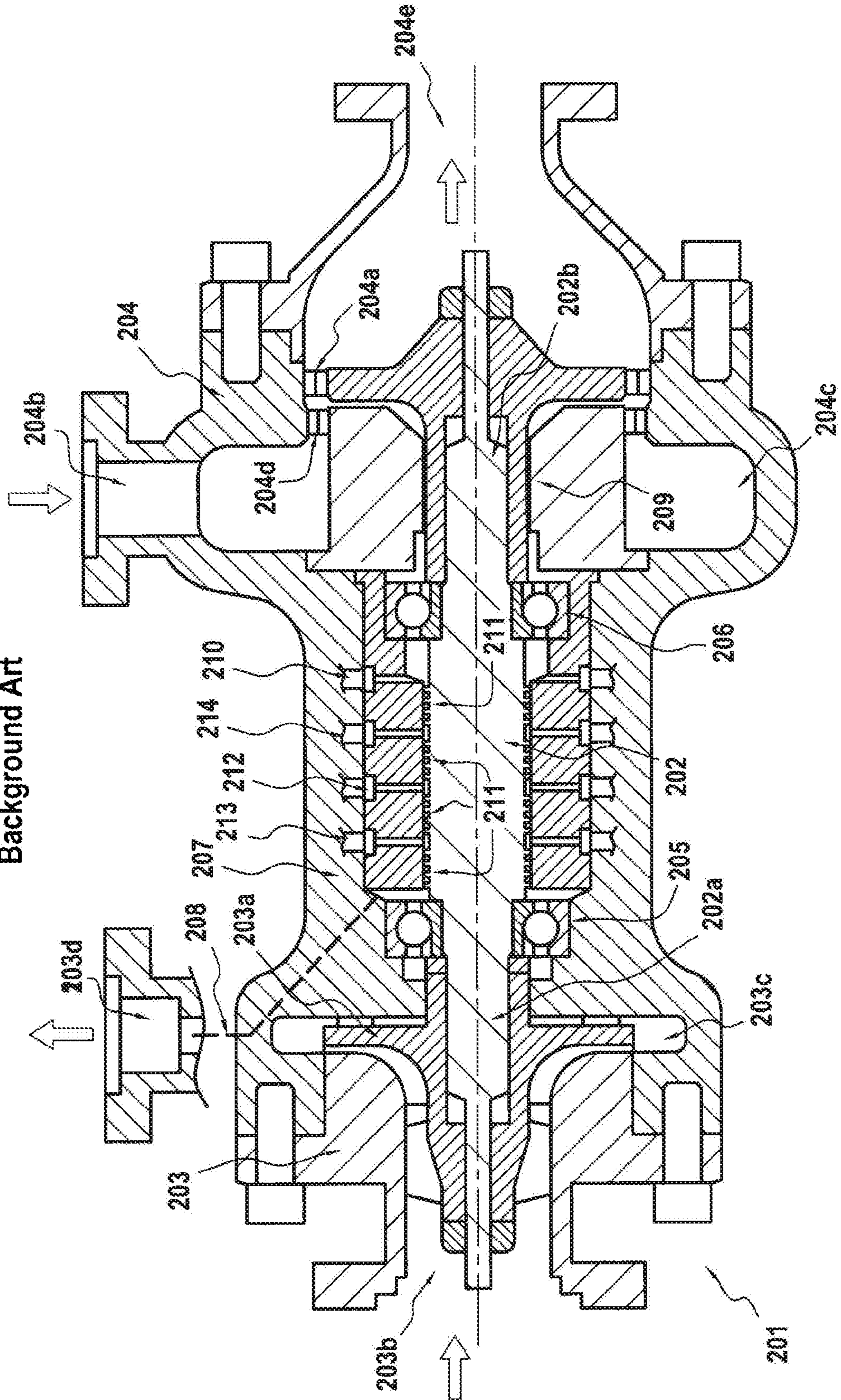
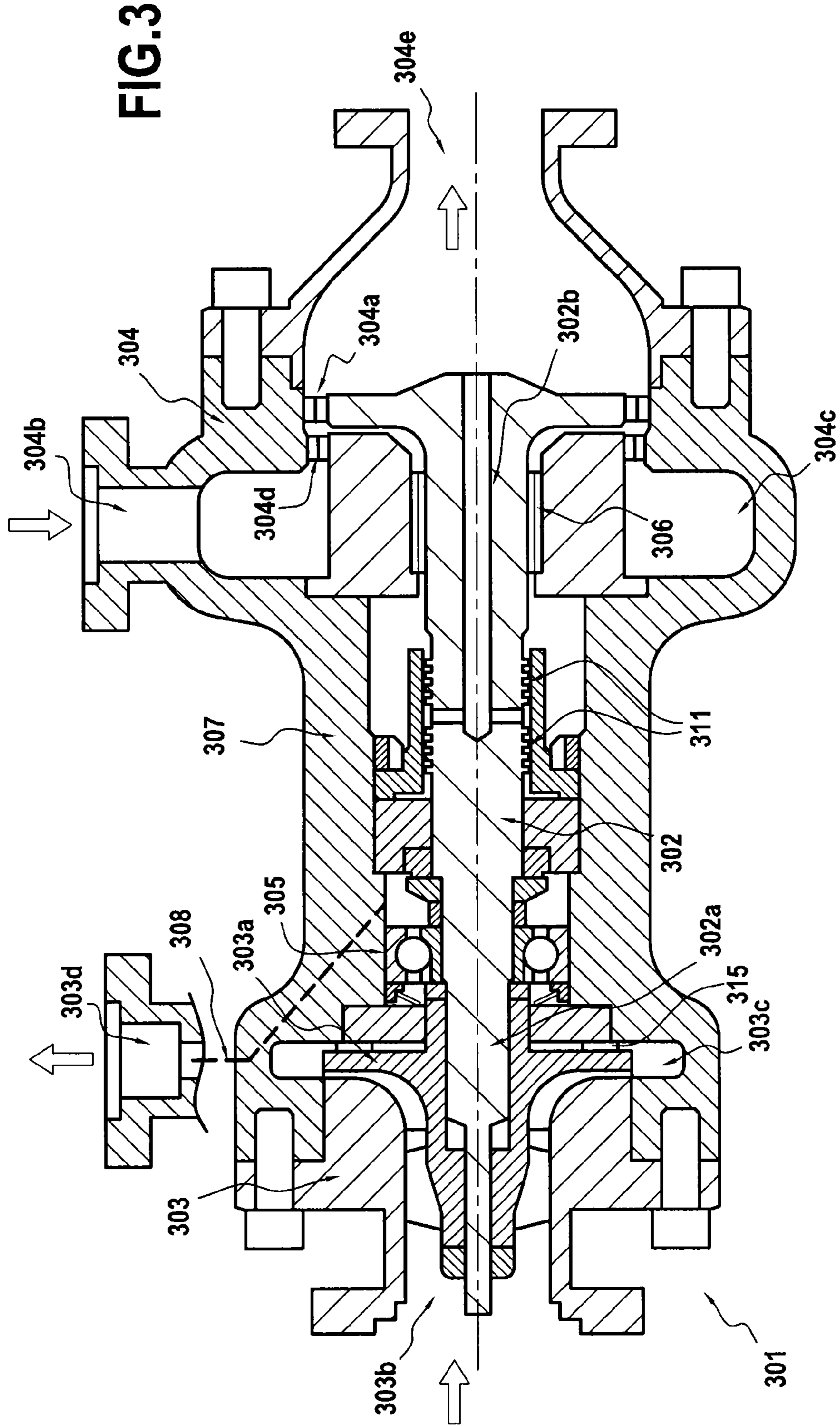


FIG. 2

Background Art





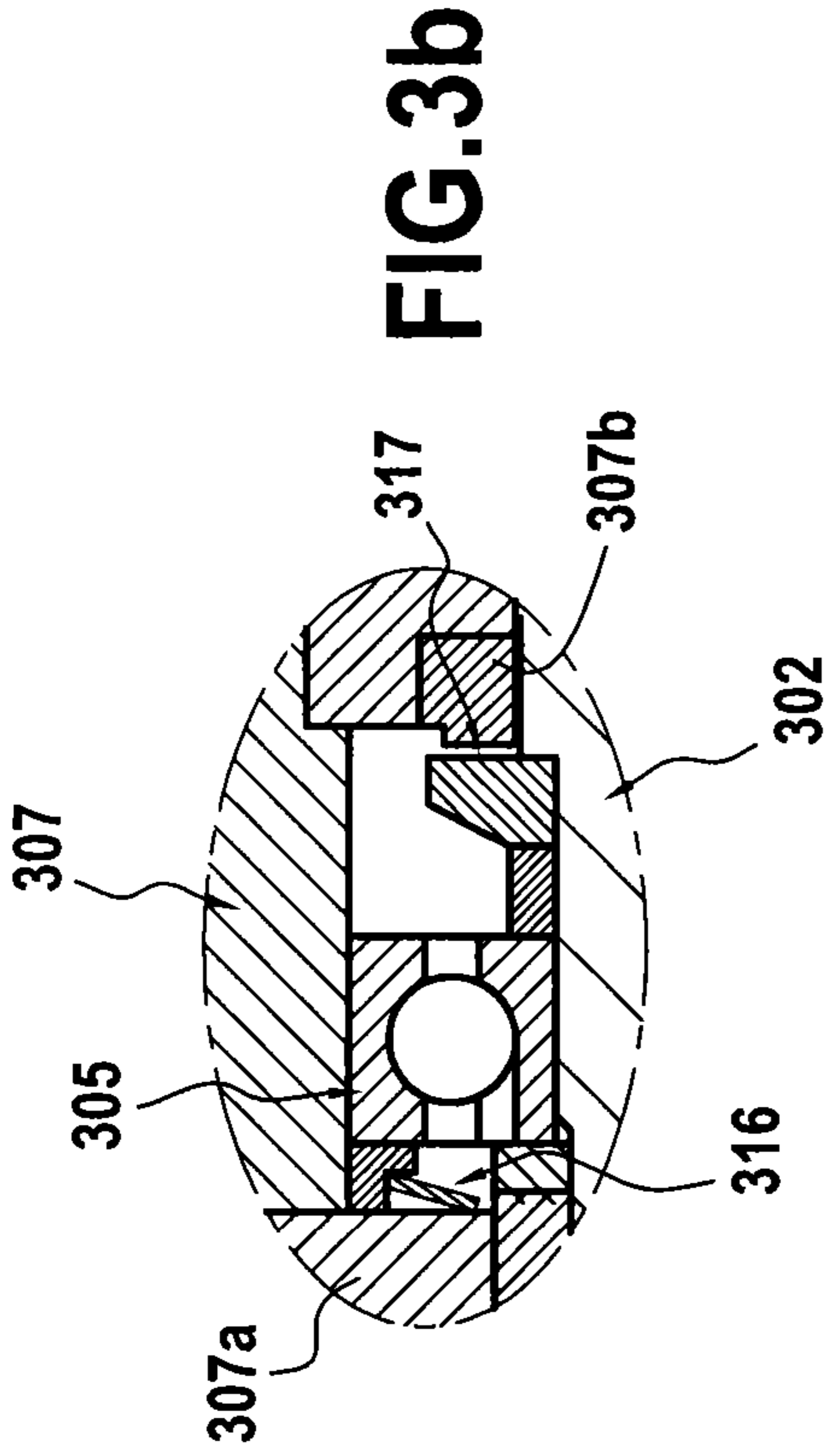


FIG. 3a

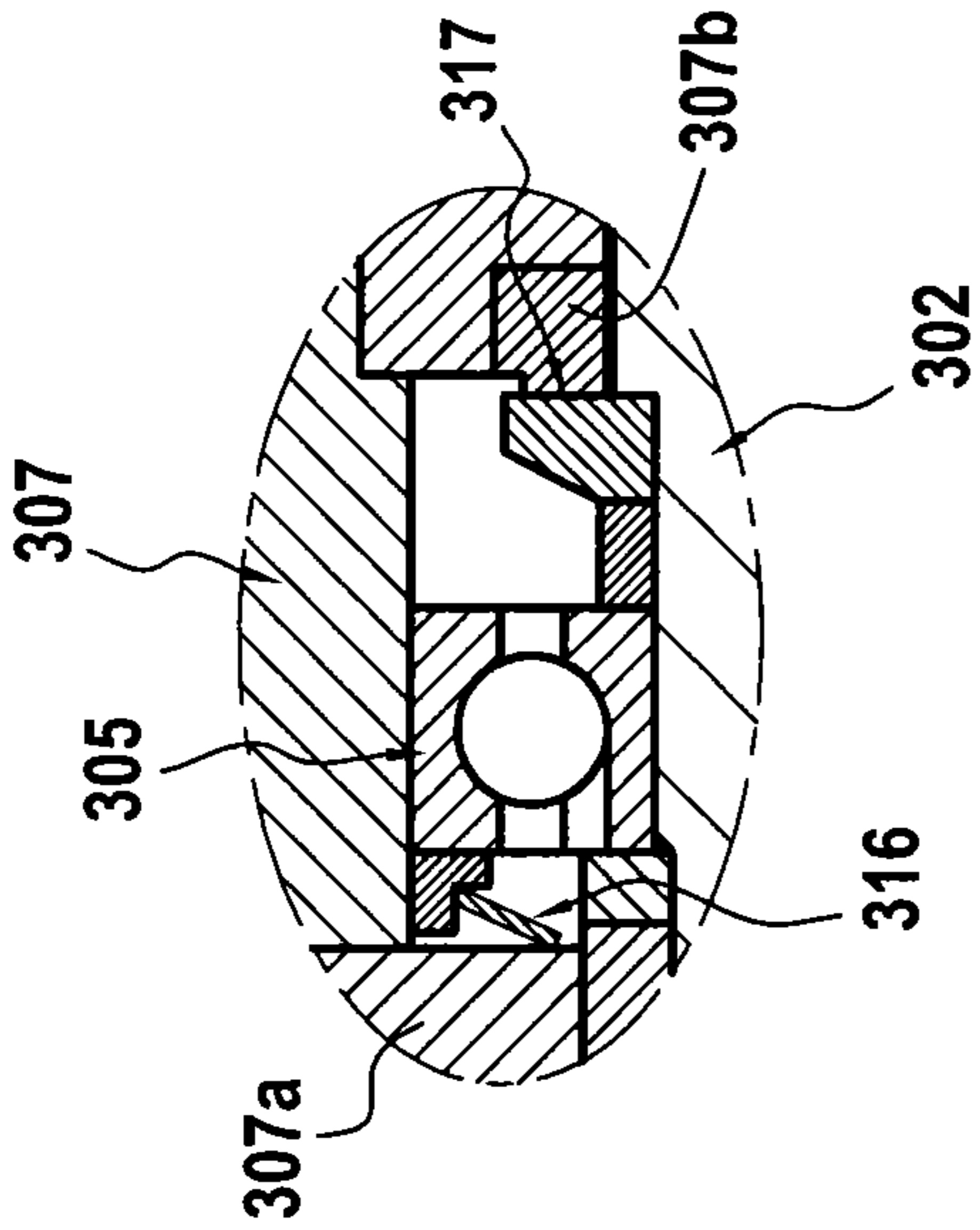


FIG. 3b

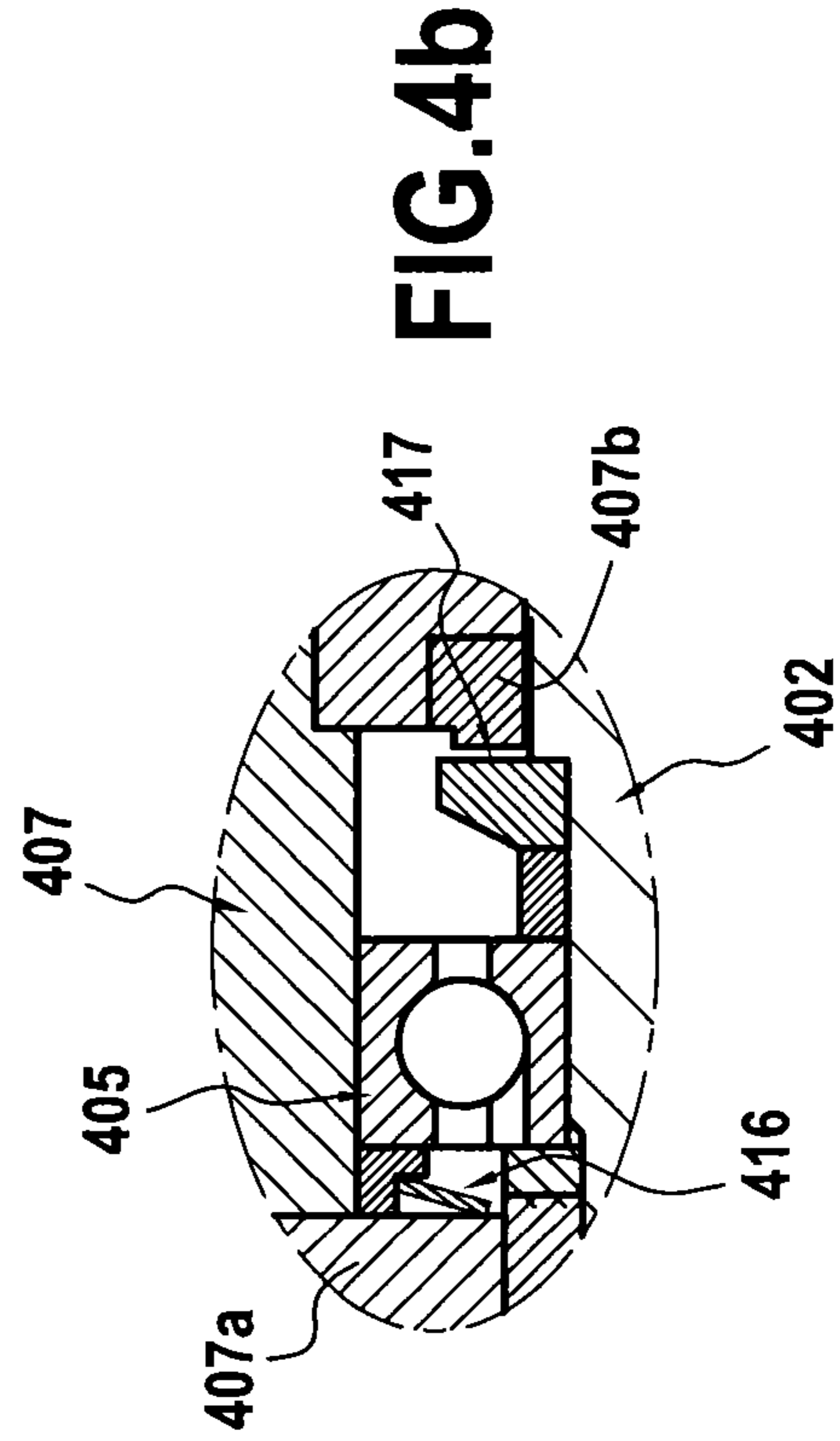


FIG. 4a

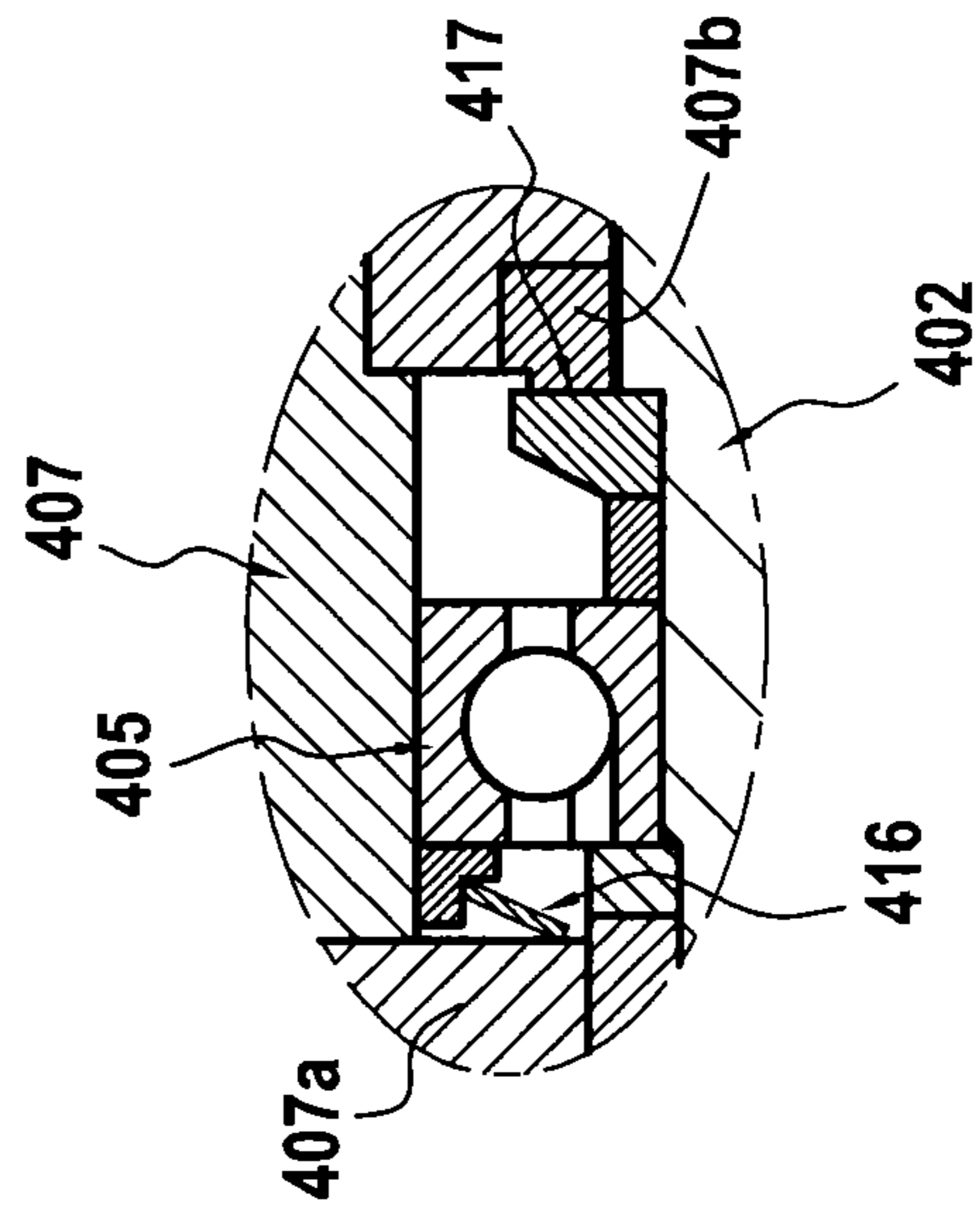
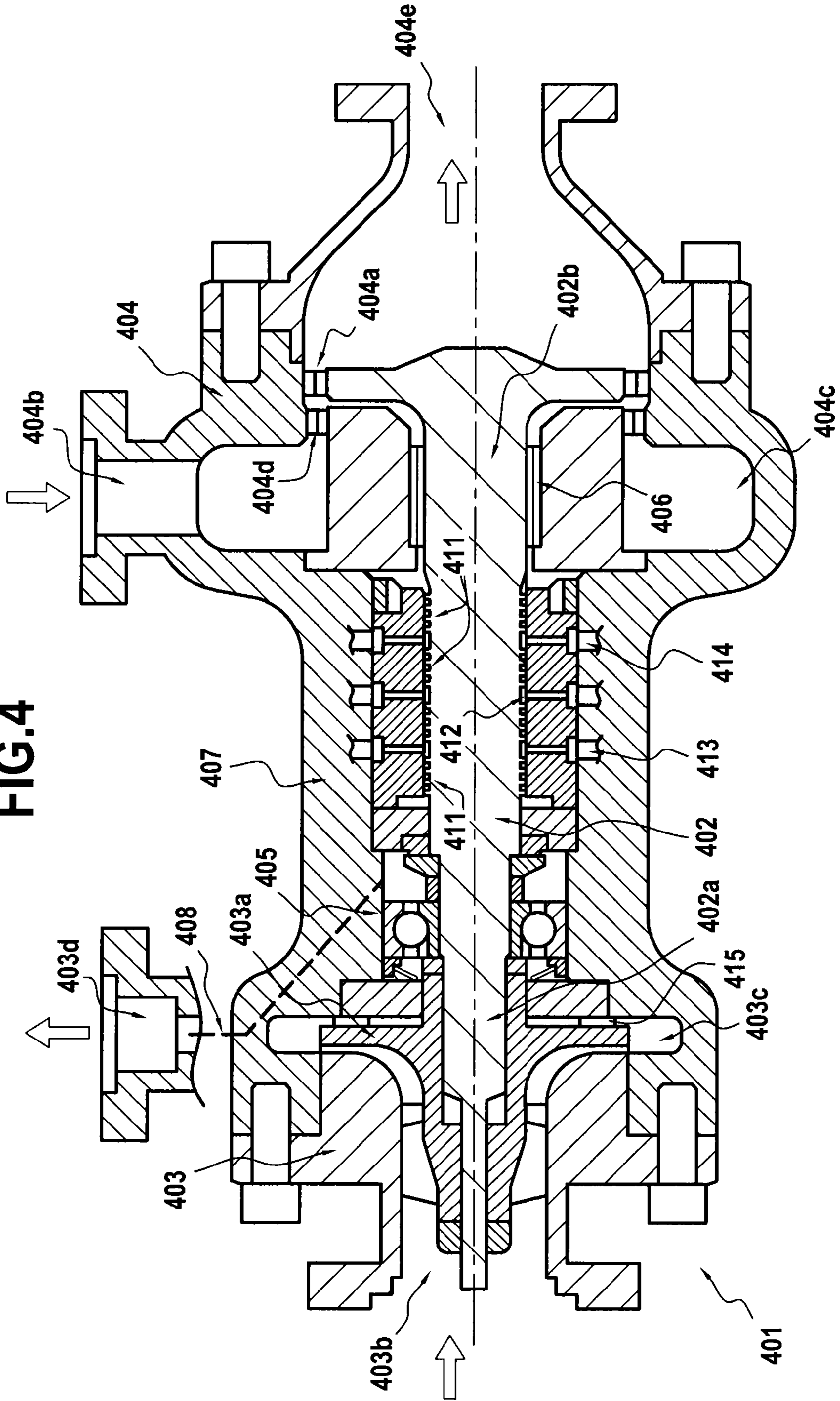


FIG. 4b

FIG. 4



TURBOPUMP, IN PARTICULAR FOR FEEDING ROCKET ENGINES

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

The present invention relates to turbopumps, and in particular turbopumps for feeding the combustion chambers of rocket engines with fuel and/or oxidizer propellants, and more particularly with cryogenic propellants.

2. Description of the Related Art

A turbopump comprises a pump and a turbine connected together by a common rotary shaft so that the rotation of the turbine rotor drives rotation of the pump rotor. Typically, in order to minimize the weight and the size of the turbopump, the common shaft is supported by first and second bearings, the first bearing being closer to the pump and the second bearing being closer to the turbine. The pump and turbine rotors are thus normally cantilevered out respectively from the first and second bearings.

Given the constraints to which turbopumps are normally subjected, in terms of speed of rotation, torque, and vibration, it is normally necessary to lubricate the bearings. A solution that has been generally adopted in the field of turbopumps for feeding propellants to rocket engines, and in particular cryogenic propellants, is to lubricate the bearings with the pumped fluid. Nevertheless, that presents the drawback of normally requiring a sealing barrier between the second bearing supporting the end of the shaft connected to the turbine and the turbine itself. Such a sealing barrier occupies a certain amount of space, thereby increasing the extent to which the turbine is cantilevered out, thereby penalizing the dynamic behavior of the shaft.

It is even more important to achieve sealing between the gas propelling the turbine and the pumped fluid when said gas and said fluid react chemically with each other. In particular, in turbopumps for feeding rocket engines with propellant, the gas propelling the turbine is normally a fuel gas, which generally requires absolute sealing within oxidizer turbopumps in order to separate the pumped oxidizer fluid from the fuel gas propelling the turbine. Under such circumstances, proposals have been made to lubricate the second bearing, i.e. the bearing supporting the shaft beside the turbine, not with the fluid that is pumped by the turbopump, but with a fuel fluid, and to separate this fuel fluid from the pumped oxidizer fluid that also lubricates the first bearing beside the pump, by using a dynamic gasket around the shaft between the two bearings, with an inert fluid being injected therein so as to provide absolute separation between the oxidizer and fuel fluid. That solution is nevertheless complex and difficult to incorporate in a turbopump of small dimensions. In addition, it does not spare the turbopump from the need to incorporate another sealing barrier between the second bearing and the turbine, with the drawbacks as mentioned above.

BRIEF SUMMARY OF THE DISCLOSURE

The present invention seeks to remedy those drawbacks. This object is achieved by the fact that, in a turbopump in at least one embodiment of the invention, the second bearing, i.e. the bearing closer to the turbine, is a hydrodynamic bearing connected to a supply source of gas that is compatible with the gas feeding the turbine, the turbopump also including a dynamic sealing gasket around the shaft, which gasket is interposed between said second bearing and the first bearing, i.e. the bearing closer to the pump.

By means of these arrangements, the second bearing no longer needs to be fed with a lubricant fluid distinct from the gas propelling the turbine. There is thus no longer any need to incorporate a sealing barrier between the second bearing and the turbine, thus making it possible to reduce significantly the extent to which it is cantilevered out.

Advantageously, the pump of the turbopump may be a cryogenic fluid pump. In this turbopump of the invention, since the second bearing is no longer necessarily fed with cryogenic fluid, this arrangement makes it possible to cool only a small portion of the turbopump, which portion is restricted to the pumps and their bearings. Furthermore, this makes it possible to minimize leaks of cryogenic fluid and to reduce consumption of the barrier gas, e.g. gaseous helium, during the period of cooling down the pump.

Advantageously, said pump is a propellant pump, in particular an oxidizer or a fuel propellant pump. This arrangement for the turbopump makes it possible to obtain compactness and lightness that are particularly advantageous in systems for feeding propellants, in particular for rocket engines, while also providing particularly advantageous sealing in the handling of chemically reactive fluids such as propellants.

Advantageously, said dynamic sealing gasket is connected to a source of inert fluid, so as to create a fluid barrier between the gas of the hydrodynamic bearing and the gas of the first bearing. Such a fluid barrier makes it possible to obtain a particularly high degree of sealing, and is therefore particularly advantageous when it is necessary to separate different fluids, e.g. because of their chemical reactivity.

Advantageously, said first bearing is connected to the pump to feed the first bearing with fluid coming from the pump. Thus, the pumped fluid can serve for lubricating the first bearing, thereby making it possible to maintain a comparatively simple arrangement for the turbopump that is reliable and light in weight and compact. Still more particularly, the first bearing may be a rolling bearing, providing very low resistance to rotation of the shaft, even at very high speeds of rotation, such as those that are normally to be found in an operating turbopump. Also more particularly, said pump may further include an auxiliary pump, preferably driven by said shaft, for evacuating said fluid from the first bearing. In particular, when the pump is a centrifugal pump, the auxiliary pump may be in the form of a backpump with blades formed on a rear face of a rotor of the pump. This makes it possible to direct the evacuation of the fluid, and in particular to return it to a main flow from the pump.

In a particularly advantageous embodiment of the present invention, said common shaft may be suitable for adopting a rest position in which it closes a static joint around said shaft, and for being moved axially from said rest position to a working position against a return force exerted by at least one resilient element. Thus, at rest, the static joint substantially prevents any leakage of fluid from the first bearing towards the dynamic gasket and the second bearing. In contrast, in the working position, the static joint no longer makes any contact, thereby avoiding friction. This arrangement thus makes it easier to fill the first bearing with the fluid prior to starting the turbopump. In particular, in cryogenic pumps, this makes it easier to cool the pump down before starting, while limiting leaks of cryogenic fluid.

The present invention also provides a method of using the turbopump, wherein the first bearing is lubricated by the fluid coming from the pump, said static joint substantially preventing said lubricating fluid from going towards the dynamic gasket and the second bearing when the turbopump

3

is stopped, and then opening when the turbopump starts by virtue of the shaft moving axially towards the pump.

More particularly, said pump may present an axial admission passage situated at an end of the pump that is remote from said first bearing, and said working position is situated towards the pump relative to said rest position. After the turbopump has started, the axial force exerted on the shaft in reaction to the suction generated by the pump on its admission passage therefore moves the shaft towards the working position in automatic manner.

Still more advantageously, in order to define said working position, an element that is axially secured to the shaft but free to rotate relative to the shaft may come into abutment against a stator secured to a casing of the turbopump towards the pump in said working position. In particular, said element that is axially secured to the shaft but free to rotate relative to the shaft may be secured to an outer raceway of the first bearing.

Also still more advantageously, in order to define said rest position, an axial element secured to the shaft may come into abutment against a stator secured to the casing of the turbopump towards the turbine in said rest position.

In a first alternative, in particular when the turbine is a gas turbine that operates at moderate temperature, the gas supply source of the hydrodynamic bearing may be the turbine itself. This simplifies the arrangement of the turbine.

In a second alternative, in particular when the turbine is a turbine that operates with hot gas and the turbopump is a turbopump for feeding a propulsion chamber with propellant, said gas supply source of the hydrodynamic bearing may be an outlet from a regenerative circuit of the propulsion chamber.

The invention also provides a rocket engine having at least one turbopump of the invention for feeding at least one propulsion chamber of said rocket engine with at least one propellant, e.g. a fuel fluid and/or an oxidizer fluid.

Because of the compactness, the light weight, the reliability, and the simplicity of the turbopump of the invention, it is particularly advantageous for application to rocket engines, in particular to rocket engines of very low thrust, and those using cryogenic propellants.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The invention can well be understood and its advantages appear better on reading the following detailed description of embodiments shown as non-limiting examples. The description refers to the accompanying drawings, in which:

FIG. 1 is a longitudinal section view of a turbopump of the prior art for feeding a rocket engine combustion chamber with a cryogenic liquid fuel propellant;

FIG. 2 is a longitudinal section view of a prior art turbopump for feeding a rocket engine combustion chamber with a cryogenic liquid oxidizer propellant;

FIG. 3 is a section view of a turbopump in a first embodiment of the invention for feeding a rocket engine combustion chamber with a cryogenic liquid fuel propellant;

FIG. 3a is a detail view of the FIG. 3 turbopump in a rest position;

FIG. 3b is a detail view of the FIG. 3 turbopump in a working position;

FIG. 4 is a section view of a turbopump in a second embodiment of the invention for feeding a rocket engine combustion chamber with a cryogenic liquid oxidizer propellant;

4

FIG. 4a is a detail view of the FIG. 4 turbopump in a rest position; and

FIG. 4b is a detail view of the FIG. 3 turbopump in a working position.

DETAILED DESCRIPTION OF THE DISCLOSURE

In order to better understand the invention, the description begins with two turbopumps **101** and **201** of the prior art as shown in FIGS. 1 and 2. In the fuel propellant turbopump **101** shown in FIG. 1, a common shaft **102** connects the centrifugal pump **103** to the axial turbine **104**. A first end **102a** of the shaft **102** is secured to a rotor **103a** of the pump **103**, and a second end **102b** of the shaft **102**, opposite from said first end **102a**, is secured to a rotor **104a** of the turbine **104**. Thus, the rotor **104a** of the turbine **104** is propelled in rotation by the expansion of gas entering into the turbine via a radial admission duct **104b**, an admission torus **104c**, and a nozzle **104d**, and leaving via an axial exhaust duct **104e**, and this rotation drives the shaft **102** and the rotor **103a** of the centrifugal pump **103** in rotation. The fuel propellant, driven by the rotor **103a**, enters into the pump **103** via the axial admission passage **103b** and leaves via the volute **103c** and the exhaust tube **103d**.

Two rolling bearings **105** and **106** support the shaft **102** in the casing **107** of the turbopump **101**. The first bearing **105** supports the first end **102a** of the shaft **102**, while the second bearing **106** supports the second end **102b** of the shaft **102**, in such a manner that the pump **103** and the turbine **104** are cantilevered out respectively from the first bearing **105** and the second bearing **106**.

In order to lubricate the bearings **105** and **106** and minimize friction between solid surfaces, a small flow **108** of liquid propellant under pressure is taken from the exhaust tube **103** and reinjected into the casing **107** of the turbopump **101** in order to immerse the bearings **105** and **106** in liquid. In order to limit losses of liquid propellant to the axial exhaust duct **104e** of the turbine **104**, a dynamic sealing gasket **109** separates the bearings **105** and **106** from the turbine **104**. Nevertheless, this gasket **109** occupies a certain amount of space and causes the turbine **104** to be cantilevered out farther.

The oxidizer propellant turbopump **201** shown in FIG. 2 likewise presents a common shaft **202** connecting the centrifugal pump **203** to the axial turbine **204**. As in the turbopump **101**, a first end **202a** of the shaft **202** is secured to a rotor **203a** of the pump **203**, and a second end **202b** of the shaft **202**, opposite from the first end **202a**, is secured to a rotor **204a** of the turbine **204**.

In the turbopump **201**, the centrifugal pump **203** also presents an axial admission passage **203b**, a volute **203c**, and an exhaust tube **203d**. The turbine **204** also presents a radial admission duct **204b**, an admission torus **204c**, a nozzle **204d**, and an axial exhaust duct **204e**. The pump **203** and turbine **204** operate in analogous manner to the pump and the turbine in the turbopump **101**, and as in the turbopump **101**, the shaft **202** is also supported by two bearings **205** and **206** that leave the pump **203** and the turbine **204** cantilevered out. Nevertheless, in the oxidizer turbopump **201**, it is more important to avoid any leaks of the propellant pumped by the pump **203** reaching the turbine **204** since the gas propelling the turbine **204** is usually a fuel gas and could react violently with the oxidizer propellant pumped by the pump **203**.

Thus, in this turbopump **201**, a small flow **208** of liquid propellant under pressure is likewise taken from the exhaust tube **203d** and reinjected into the casing **207**, however it is

used only for lubricating the first bearing **205** adjacent to the pump **203**. The second bearing **206** is lubricated by a small flow **210** of the fuel fluid, taken from elsewhere. As in the above-described turbopump **101**, a dynamic sealing gasket **209** limits leaks of this fuel fluid towards the turbine **204**. Nevertheless, in order to avoid contact between the flow **208** of oxidizer fluid and the flow **210** of fuel fluid, the turbopump **201** also presents between the first and second bearings **205** and **206**: a plurality of dynamic sealing gaskets **211** around the shaft **202**; an injection point **212** for injecting an inert fluid, such as helium, for example; and bleed points **213**, **214** for bleeding off the oxidizer fluid and the fuel fluid respectively on opposite sides of the injection points **212**. In this way, a fluid barrier is created between the oxidizer and fuel fluid.

These prior art turbopumps **101** and **201** nevertheless present a certain amount of complexity, including a turbine that is cantilevered out. In a first embodiment of the invention as shown in FIGS. **3**, **3a**, and **3b**, the turbopump **301**, which is a fuel propellant turbopump, also includes, like the prior art turbopump described above, a common shaft **302** connecting the centrifugal pump **303** to the axial turbine **304**, with a first end **302a** of the shaft **302** secured to a rotor **303a** of the pump **303**, and a second end **302b** of the shaft **302**, opposite from said first end **302a**, secured to a rotor **304a** of the turbine **304**.

The centrifugal pump **303** also presents an axial admission passage **303b**, a volute **303c**, and an exhaust tube **303d**, and the turbine **304** presents a radial admission duct **304b**, an admission torus **304c**, a nozzle **304d**, and an axial exhaust duct **304e**. The pump **303** and turbine **304** operate in a manner analogous to the pump and the turbine of the prior art turbopumps **101** and **201**, and the shaft **302** is likewise supported by first and second bearings **305** and **306**. A small flow **308** of liquid propellant under pressure is also taken from the exhaust tube **303d** and reinjected into the casing **307** to lubricate the first bearing **305** beside the pump **303**, which bearing is likewise a rolling bearing. This fluid is then evacuated to the volute **303c** by a backpump **315** having blades formed on a rear face of the rotor **303a** of the pump **303**.

Nevertheless, in this turbopump **301** constituting a first embodiment of the invention, the second bearing **306** supporting the second end **302a** of the shaft **302** close to the turbine **304** is a hydrodynamic bearing in which a thin stream of propellant gas for the turbine **304**, taken from its admission torus **304c**, prevents direct contact between facing solid surfaces. The use of a hydrodynamic bearing to support the shaft **302** radially at the turbine end **304** makes it possible to omit a dynamic sealing gasket between the second bearing **306** and the turbine **304**. Also, because of its small radial extent, it enables the bearing **306** to be incorporated closer to the turbine rotor **304a**, minimizing or even completely eliminating the cantilever of the rotor **304a** relative to the bearing **306**. In addition, because of this small radial extent, it also allows the shaft to be of large diameter in register with the bearing **306**, which is also most favorable for the dynamic behavior of the shaft **302**.

In the embodiment shown, the gas for the hydrodynamic bearing **306** is taken from the admission torus **304c**, but in an alternative it could be taken from elsewhere, for example, if the temperature of the turbine propulsion gas is too high, from the outlet of a regenerator circuit of a propulsion chamber.

In order to separate the gas of the hydrodynamic bearing **306** from the liquid of the rolling bearing **305** while the turbopump **301** is in operation, this turbopump **301** includes

dynamic sealing gaskets **311** around the shaft **302** between the rolling bearing **305** and the hydrodynamic bearing **306**, with a bleed point leading to the axial exhaust duct **304e**. Nevertheless, this turbopump **301** also includes a facial contact sealing device beside the first bearing **305** so as to provide additional sealing between the two bearings **305** and **306** when the turbopump **301** is stopped. The operation of this sealing device is shown in detail in FIGS. **3a** and **3b**.

In FIG. **3a**, the sealing device can be seen in its rest position, while the turbopump **301** is stopped. A resilient element **316**, specifically a spring washer interposed between an outer raceway of the bearing **305** and a stator **307a** secured to the casing **307** of the turbopump **301** urges the bearing **305** together with the shaft **302** towards the turbine **304** into this rest position, in which an element that is axially secured to the shaft **302** comes into abutment against an opposite surface of a stator **307b** secured to the casing **307** of the turbopump **301**, thereby closing a seal **317** around the shaft **302** between the first bearing **305** and the dynamic sealing gaskets **311**.

Thus, this static sealing device makes it easier to cool the bearing **305** down when at rest, and enables it to be immersed in cryogenic liquid without significant leakage towards the turbine **304**. Nevertheless, when the turbopump **301** starts to operate, the suction exerted by the pump **303** on the axial admission passage **303b** exerts axial traction through the rotor **303a** on the shaft **302** towards the pump **303** and against the resilient element **316**, thereby opening the static seal **317**, and until coming into abutment against a stator **307a** secured to the casing **307** towards the pump **303**. This working position in which an element secured to the outer raceway of the bearing **305** is in abutment against a stator **307a** secured to the casing **307** going towards the pump **303** is shown in FIG. **3b**. Since the static seal **317** is thus open while the turbopump **301** is rotating normally, it generates no significant friction.

In a second embodiment of the present invention, as shown in FIGS. **4**, **4a**, and **4b**, the turbopump **401** is an oxidizer propellant turbopump. Like the above-described turbopump, it likewise has a common shaft **402** connecting the centrifugal pump **403** to the axial turbine **404**, with a first end **402a** of the shaft **402** secured to a rotor **403a** of the pump **403**, and a second end **402b** of the shaft **402**, opposite from said first end **402a**, being secured to a rotor **404a** of the turbine **404**.

The centrifugal pump **403** also presents an axial admission passage **403b**, a volute **403c**, and an exhaust tube **403d**, and the turbine **404** presents a radial admission duct **404b**, an admission torus **404c**, a nozzle **404d**, and an axial exhaust duct **404e**. The pump **403** and the turbine **404** operate in a manner analogous to the pump and turbine of the above-described turbopumps, and the shaft **402** is likewise supported by first and second bearings **405** and **406**. A small flow **408** of liquid propellant under pressure is also taken from the exhaust tube **403d** and reinjected into the casing **407** in order to lubricate the first bearing **405** beside the pump **403**, which is likewise a rolling bearing. This fluid lubricating the bearing **405** is also evacuated therefrom towards the volute **403c** by a backpump **415** having blades formed on a rear face of the rotor **403a** of the pump **403**.

As in the first embodiment, the second bearing **406** supporting the second end **402a** of the shaft **402** beside the turbine **404** is a hydrodynamic bearing in which a thin stream of gas for propelling the turbine **404** that is taken from its admission torus **404c** prevents direct contact between facing solid surfaces. Alternatively, this gas can be taken from elsewhere, e.g., at the outlet from a regenerative

circuit of a propulsion chamber, if the temperature of the turbine propulsion gas is too high.

In this second embodiment, the use of a hydrodynamic bearing presents the same advantages as in the first embodiment. Nevertheless, as in the prior art turbopump **201** shown in FIG. **2**, it is important in this oxidizer turbopump **401** to provide very good sealing between the fuel gas of the hydrodynamic bearing **406** and the oxidizer fluid that is pumped by the pump **403**. For this purpose, this turbopump **401** includes, between the rolling bearing **405** and the hydrodynamic bearing **406**, firstly additional dynamic sealing gaskets **411** around the shaft **402**, an injection point **412** for injecting an inert gas, such as helium for example, and bleed points **413**, **414** for bleeding off the oxidizer fluid and the fuel gas respectively on either side of the injection point **412**. This serves to create a fluid barrier between the oxidizer fluid and the fuel gas.

As in the first embodiment, this turbopump **401** also includes a facial contact sealing device beside the first bearing **405**, providing additional sealing between the two bearings **405** and **406** when the turbopump **401** is stopped. The operation of this sealing device is shown in detail in FIGS. **4a** and **4b** and is analogous to the operation of the first embodiment, with a resilient element **416** urging the bearing **405** and the shaft **402** into a rest position as shown in FIG. **4a**, towards the turbine **404** so as to close a seal **417** around the shaft **402** between the bearing **405** and the dynamic sealing gasket **411**, and a working position as shown in FIG. **4b**, in which the suction generated by the pump **403** at the axial admission passage **403b** exerts traction on the pump rotor **403a** and on the shaft **402**, thereby moving the shaft **402** and the bearing **405** towards the pump **403** so as to open the seal **417**.

The turbopumps **301** and **401** can be used in particular for feeding a propulsion chamber (not shown) of a rocket engine with propellant, and more specifically respectively with a cryogenic liquid fuel and a cryogenic liquid oxidizer. They are particularly suitable for feeding low thrust rocket engines.

Although the present invention is described above with reference to specific embodiments, it is clear that various modifications and changes may be implemented on those embodiments without going beyond the general scope of the invention as defined by the claims. Consequently, the description and the drawings could be considered in a sense that is illustrative rather than restrictive.

The invention claimed is:

1. A turbopump, comprising:
 - a propellant pump;
 - a turbine;
 - a common rotary shaft connected to said propellant pump and to said turbine;
 - a first bearing and a second bearing, the first and second bearings supporting said common rotary shaft, said first bearing being closer than the second bearing to the propellant pump, and said second bearing being closer than the first bearing to the turbine; and
 - at least one dynamic sealing gasket around the common rotary shaft interposed between said first and second bearings,

wherein said second bearing is a hydrodynamic bearing connected to a gas supply source so that no seal is interposed between the second bearing and the turbine.

2. The turbopump according to claim 1, wherein said propellant pump is a cryogenic fluid pump.

3. The turbopump according to claim 1, wherein said dynamic sealing gasket is connected to a source of inert fluid.

4. The turbopump according to claim 1, wherein said first bearing is connected to the propellant pump to lubricate the first bearing with fluid coming from the propellant pump.

5. The turbopump according to claim 4, wherein said first bearing is a rolling bearing.

6. The turbopump according to claim 4, further comprising:

- an auxiliary pump to exhaust said fluid from the first bearing.

7. The turbopump according to claim 4, wherein said common rotary shaft adopts a rest position in which a facial contact seal is closed around the common rotary shaft, and is movable in a movement axially from said rest position to a working position in which said facial contact seal is open, the movement being against a return force exerted by at least one resilient element.

8. The turbopump according to claim 7, wherein said propellant pump presents an axial admission passage situated at an end of said propellant pump that is remote from said first bearing, and said working position is situated towards the propellant pump relative to said rest position.

9. The turbopump according to claim 8, wherein, in said working position, an axial element secured to the common rotary shaft but free to rotate relative to the common rotary shaft comes into abutment, towards the propellant pump, against a stator secured to a casing of the turbopump.

10. The turbopump according to claim 8, wherein, in said rest position, an axial element secured to the common rotary shaft comes into abutment, towards the turbine, against a stator secured to a casing of the turbopump.

11. The turbopump according to claim 1, wherein said gas supply source for the hydrodynamic bearing is the turbine.

12. An assembly, comprising:

- the turbopump according to claim 1; and
- a propulsion chamber, wherein said gas supply source for the hydrodynamic bearing is an outlet from a regenerative circuit of the propulsion chamber.

13. A rocket engine, comprising:

- at least one propulsion chamber; and
- the turbopump according to claim 1 to feed at least one propellant to said at least one propulsion chamber.

14. A rocket engine, comprising:

- the assembly according to claim 12.

15. A method of using the turbopump according to claim 7, wherein the first bearing is lubricated by the fluid coming from the propellant pump, the method comprising:

- preventing, with said facial contact seal, said lubricating fluid from passing towards the dynamic sealing gasket and the second bearing when the turbopump is stopped; and
- opening said facial contact seal by axial movement of the common rotary shaft when the turbopump is started.